

SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT
NPDES PERMIT RENEWAL

TESTIMONY/COMMENTS OF DIANA L. ENGLE, Ph.D.
of LARRY WALKER ASSOCIATES

On

THE POTENTIAL ROLES OF AMMONIA AND NUTRIENT RATIOS IN THE
UPPER SAN FRANCISCO ESTUARY

On behalf of the

SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT

I am Dr. Diana L. Engle. I am a Senior Scientist at Larry Walker Associates, an environmental science and engineering firm based in Davis, California. I am an aquatic ecologist with over 20 years of experience evaluating the ecology and biogeochemistry of lakes, streams, large rivers and floodplains, estuaries, and wetlands. My education includes a Bachelor of Science degree in Biology from the University of Michigan, Ann Arbor, and a doctorate in aquatic and population biology from the University of California, Santa Barbara. I have authored extensive assessments of water quality in coastal and inland environments of California, and have published peer-reviewed articles on topics including floodplain nutrient dynamics, carbon cycling, watershed mass balances and stream export, and the ecology of aquatic macrophytes, floodplain algae, and riverine and lacustrine zooplankton. I work in the Ventura, California office of Larry Walker Associates, and assist clients in such areas as water quality assessment and monitoring, contaminant source assessment, watershed balances, fate and transport of nutrients and other constituents, aquatic chemistry, algal and food web dynamics, and other areas of nexus between water quality regulation and aquatic ecology. A copy of my Curriculum Vitae is attached.

Professional Experience Related to the San Francisco Estuary

On behalf of Sacramento Regional County Sanitation District (District) and other clients, I am responsible for tracking research results and other developments related to hypothesized direct and indirect roles of ammonia and other nutrients in the upper San Francisco Estuary (SFE). In that capacity, I provide written and oral responses to work plans and work products of bodies including state and federal task forces (such as Gov. Schwarzenegger's Delta Vision Blue Ribbon Task Force, National Academy of Science Committee to Review Sustainable Water and Environmental Management in the California Bay-Delta), State Water Resources Control Board (e.g., Bay-Delta Plan, Delta Flow Criteria), Central Valley and San Francisco Regional Water Quality Control Boards, Interagency Ecological Program (IEP), CALFED, Delta Regional Ecosystem

Restoration Implementation Plan, Bay-Delta Conservation Plan (BDCP), the Delta Stewardship Council, and academic and agency scientists that are engaged in contaminant- and food web-related research in the SFE.

I also regularly attend and present findings at SFE-related workshops and conferences. In March 2010, I submitted extensive written testimony and was selected to serve on one of four panels providing oral testimony (Other Stressors: Water Quality Panel) before the State Water Resources Control Board at the Informational Proceeding to Develop Flow Criteria for the Delta Ecosystem. I serve as a member of the IEP POD Contaminants Work Team and its Ammonia Subcommittee. I was an invited panel member at both the CalFed March 2009 Ammonia Workshop and the Central Valley Regional Board August 2009 Ammonia Summit, and an invited speaker at the October 2009 IEP Workshop: Bay-Delta Monitoring Questions & Tools for the 21st Century. I presented comprehensive analyses of ambient ammonia data from the San Francisco Estuary at the 9th Biennial State of the San Francisco Estuary Conference in September 2009, and at the May 2010 IEP Annual Workshop. I presented the results of a comprehensive literature review on the feeding biology of estuarine copepods at the Sept. 2010 6th Biennial Bay-Delta Science Conference. In addition, I have compiled and maintain a comprehensive regional water quality database for the Bay-Delta, which I have used to screen three decades of ambient ammonia data using current and proposed USEPA acute and chronic criteria, to examine Nitrogen:Phosphorus (N:P) ratios in the estuary, and to evaluate relationships among ammonia concentrations, estuarine flows and water exports, and phytoplankton and fish abundance. I was recently invited to serve as a member of a Transition Advisory Committee (TAC) for proposed research to develop a DNA-array-based diagnostic tool for fast and accurate detection of harmful and toxic cyanobacteria in estuarine environments through NOAA's Prevention, Control, and Mitigation of Harmful Algal Blooms (PCM HAB) Program.

Findings Regarding the Evidence Presented in the Tentative NPDES Permit for the Sacramento Regional Wastewater Treatment Plant (Tentative Permit) Related to the Potential Role of Ammonia and Nutrient Ratios in the San Francisco Estuary

My professional opinions regarding hypothesized direct and indirect roles of ammonia and nutrient ratios in the SFE, and my evaluation of the current state of direct knowledge regarding ammonia-related concerns in the SFE, are supported by data analyses, academic literature reviews, and other evaluations that are detailed in the following work products, electronic copies of which are included as part of the District's submittal in response to the Tentative Permit for the Sacramento Regional Wastewater Treatment Plant (SRWTP) released on September 3, 2010:

Engle, D.L. (2010) Slides and Oral Remarks Presented in: *Engle, D. (2010) How well do we understand the feeding ecology of estuarine mesozooplankton? A survey of the direct evidence. 6th Biennial Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010. 31 pp.*

Engle, D. and C. Suverkropp (2010) Memorandum: Comments for Consideration by the State Water Resources Control Board Regarding the Scientific Article *Long-term Changes in Nutrient Loading and Stoichiometry and their Relationships with*

Changes in the Food Web and Dominant Pelagic Fish Species in the San Francisco Estuary, California by Patricia Glibert. 17 pp. July 29, 2010.

Engle, D.L., & G. Lau (2010) Does Ammonia Exceed Toxicity Thresholds in the Upper San Francisco Estuary? A Comparison of Ambient Data and Toxicity Thresholds for 1974-2010. Interagency Ecological Program (IEP) Annual Workshop, Sacramento, CA, May 25-26, 2010.

Engle, D. (2010) Written Comments Regarding the Draft Report: *Foe, C., A. Ballard, and S. Fong (2010) Nutrient Concentrations and Biological Effects in the Sacramento-San Joaquin Delta. Draft Report. Central Valley Regional Water Quality Control Board, May 2010.* Submitted to Sacramento Regional County Sanitation District, June 7, 2010.

Engle, D. (2010) Testimony before State Water Resources Control Board Delta Flow Criteria Informational Proceeding. Other Stressors-Water Quality: Ambient Ammonia Concentrations: Direct Toxicity and Indirect Effects on Food Web. Submitted to the State Water Resources Control Board, 40 pp. February 16, 2010.

Engle, D. (2010) Memorandum: Comments Regarding the Regional Board Staff Analysis of the 2009 Ammonia Summit. 20 pp. January 13, 2010.

McCord, S., J. Walker, and D. Engle (2009) A pilot study using continuous ammonium sensors in the Sacramento River. Interagency Ecological Program (IEP) Workshop #5: Bay-Delta Monitoring Questions & Tools for the 21st Century, Sacramento, CA., October 9, 2009.

Engle, D.L., and G. Lau (2009) Total and Un-ionized Ammonia Concentrations in the Upper San Francisco Estuary: A Comparison of Ambient Data and Toxicity Thresholds. 9th Biennial State of the San Francisco Estuary Conference, Oakland, CA, September 29-October 1, 2009.

Engle, D. (2009) Total Ammonia and Un-Ionized Ammonia Concentrations in the Delta. An Examination of Ambient Concentrations and Toxicity Thresholds. Central Valley Regional Water Quality Control Board Ammonia Summit, Sacramento, California, August 18-19, 2009.

Engle, D., J. Walker, S. McCord, C. Irvine, and C. Williams (2009) Sacramento River Ammonia Pilot Study Results. Technical Memorandum submitted to the Interagency Ecological Program (IEP) Pelagic Organism Decline (POD) Contaminants Work Team, August 13, 2009.

I have reviewed sections of the Tentative Permit relating to the hypothesized direct and indirect effects of ammonia and N:P ratios, principally contained in Tentative Permit Attachment K - *Ammonia Related Issues* and Tentative NPDES Permitting Options Section III. *Ammonia Removal*. In addition, I am familiar with and have reviewed in detail the ammonia-related reports, articles, and oral presentations that are referenced in the Tentative Permit regarding hypothesized direct and indirect effects of ammonia in the ecosystem of the upper SFE. I participated in the development of the sections of the District's Comments on the Tentative Permit which are listed below. The information and points presented in these sections reflect my professional opinions regarding the

evidence referenced in the Tentative Permit related to its proposed requirements for full nitrification and denitrification of the effluent from SRWTP.

Sections of the District's Comments on the Tentative Permit which contain my professional opinions:

II.A.1. The Evidence Identified in the Tentative Permit does Not Substantiate the Hypothesis That Ammonia Impacts Pelagic Organism Decline (POD) Species

II.A.2. Evidence in the Record Demonstrates That Ammonia Is Not Causing Acute or Chronic Toxicity to Delta Fish

II.A.3. Hypothesized Benefits of Ammonia Reduction in Terms of Increased Diatom Biomass in Suisun Bay Are So Uncertain as to Make a Requirement for Full Nitrification Unreasonable

II.A.4. Evidence Identified in the Tentative Permit Does Not Support That Ammonia Causes a Decrease in Chlorophyll-a or Changes the Phytoplankton Composition Downstream From the SRWTP

II.A.5. The Tentative Permit Does Not Present Evidence That a Shift in Phytoplankton Composition in the Estuary Represents a Degradation of Food Resources at the Bottom of the Food Web

II.A.6. The Copepod Toxicity Tests Referenced in the Tentative Permit are an Improper Basis for Requiring Full Nitrification

III.A. Scientific Evidence Has Not Been Presented in the Tentative Permit to Justify the Proposed Denitrification Requirements on the Basis of Protecting Aquatic Life Uses in the Delta

Curriculum Vitae

Diana L. Engle, Ph.D.

Senior Scientist

Larry Walker Associates

2151 Alessandro Avenue, Suite 100

Ventura, CA 93001

dianae@lwa.com

Education:

Ph.D. 1993, Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA

B.S. 1983, Biology, University of Michigan, Ann Arbor, MI

Areas of Expertise:

- Cycling of elements in lakes, streams, rivers, floodplains, wetlands
- Effects of nutrient inputs on aquatic plants, invertebrates, benthic algae, and phytoplankton
- Assessment of freshwater and marine water quality, sources of water quality impairment
- Effects of wildfire on stream chemistry, runoff, and nutrient export

Positions:

2008-PRESENT- **Senior Scientist**, Larry Walker Associates, 2151 Alessandro Drive, Suite 100, Ventura, CA.

2007 **Consultant** for Santa Barbara Channelkeeper, Santa Barbara, CA
Evaluation of existing, and potential, onshore and offshore sources of water quality impairment affecting the Channel Islands National Marine Sanctuary (CINMS) and the Santa Barbara Channel

2005-2007 **Research Specialist II**, University of California, Santa Barbara, CA (UCSB)

Affiliations:

Marine Science Institute

Institute for Computational & Earth System Science

Donald Bren School of Environmental Science & Management

Selected Projects

- Assessment of the ecological condition and potential impairments of aquatic resources at Channel Islands National Park, CA and Cabrillo National Monument, CA. Funded by the U.S. National Park Service.
- Analysis and modeling of carbon dynamics in Amazon wetlands. Funded by NASA (part of the Large Scale Biosphere-Atmosphere Experiment in Amazonia, or *LBA-ECO*).
- Environmentally-based Executive Education at the Bren School, UC Santa Barbara. Funded by the Dean Witter Foundation.

2005 **Analyst V**, Donald Bren School of Environmental Science & Management, UCSB
Analysis of policy and technology-based solutions to environmental problems, and development of new research initiatives. Included financial risk assessment and stakeholder

meetings with industry and agency leaders. Funded by the Paul G. Allen Family Foundation.

Agenda: Financial Instruments for Fisheries Reform
Molecular Probes for Pathogen Detection in Coastal Water
Markets for Ecosystem Services on the Agricultural Landscape

- 2005-2006 **Consultant** for Glencoe/McGraw-Hill Companies, Columbus OH
Writing, content review, editing, and fact checking for the Glencoe-Science's 2007 high school and middle school biology textbooks.
- 2002-2004 **Consultant** for U.S. National Park Service and U.S. Geological Survey, Sequoia & Kings Canyon National Parks, CA
Analysis and publication of a 16-year data set on nutrient fluxes in mixed conifer forest and the consequences of prescribed fire on stream hydrology, stream chemistry, and watershed mass balances in Sequoia National Park.
- 1996-2004 **Lecturer**, Department of Ecology, Evolution and Marine Biology, UCSB
Courses taught: Tropical Ecology, upper division (8 years: 1996-2004); Aquatic Community Ecology, upper division (3 years, 1999-2001); Undergraduate Ecology Seminar, upper division (4 years, 1996-2000)
- 1998-2002 **Consultant** for Planet Earth Science, Santa Barbara, CA
Production of interactive CD-ROMs (virtual science expeditions) and on-line courseware for junior high, high school and college students, with strong emphasis on interpretation of satellite data. Position funded by the NASA ESIP program (Earth Science Information Partnership).
Foci of Digital Products:
River Ecology, Global Warming, Hurricanes, Atmospheric Aerosols
- 1994-1997 **Post-Doctoral Researcher**, Marine Science Institute, UCSB
Assessment of potential impacts of acid deposition on high altitude aquatic ecosystems in California; Integrating ten years of investigation. Funded by the California Air Resources Board.
- 1994 **Post-Doctoral Researcher**, in connection with the Universite du Quebec, Institut National de la Recherche Scientifique, Sainte-Foy, Quebec, Canada.
Characterization of exchangeable phosphorus on riverine particulates in the Parana River system, Argentina.
- 1986-1993 **Doctoral Dissertation Researcher**, Department of Biological Sciences, UCSB
Role of riverine flooding in the ecology of floodplain lakes of the Amazon River. Extended field and laboratory work in Amazonas, Brazil.
- 1992-1993 **Graduate Research Assistant**, Department of Biological Sciences, UCSB
Monitoring and evaluation of zooplankton as bio-indicators of acidification in alpine lakes of the Sierra Nevada, CA. Funded by the California Air Resources Board.
- 1985-1993 **Teaching Assistant**, Department of Ecology, Evolution & Marine Biology, UCSB
Courses: Aquatic Ecology, Concepts of Biology, Chemical and Physical Methods for Aquatic Environments, Tropical Ecology
- 1987 **Research Assistant**, NASA Global Tropospheric Experiment, ABLE 2B: Amazon Ground Emissions.

- Field measurement of methane flux from an Amazon floodplain lake, and analysis of its relationship to episodic mixing.
- 1983-1985 **Research Assistant**, Division of Environmental Research, Academy of Natural Sciences, Philadelphia, PA.
Estuarine nutrient cycling, sediment chemistry, and denitrification in the Chesapeake and Delaware Bays.
- 1983 **Research Assistant**, Division of Biological Sciences, University of Michigan, Ann Arbor.
Lagrangian studies of zooplankton dynamics in Lake Michigan.
- 1983 **Honors Research**, University of Michigan, Ann Arbor.
Population differences in hemoglobin production by *Daphnia pulex*.
- 1982-1983 **Biological Aid**, U.S. Fish & Wildlife Service, Great Lakes Fishery Laboratory, Ann Arbor, MI.
Effects of acidification on life history characteristics of zooplankton.

Publications and Presentations:

- Engle, D.L. (2010) How well do we understand the feeding ecology of estuarine mesozooplankton? A survey of the direct evidence. 6th Biennial Bay-Delta Science Conference, Sacramento, CA, September 27-29, 2010.
- Engle, D.L., & G. Lau (2010) Does Ammonia Exceed Toxicity Thresholds in the Upper San Francisco Estuary? A Comparison of Ambient Data and Toxicity Thresholds for 1974-2010. Interagency Ecological Program (IEP) Annual Workshop, Sacramento, CA, May 25-26, 2010.
- Melack J.M., and D.L. Engle (2010) An organic carbon budget for an Amazon floodplain lake. Verh. Internat. Verein. Limnol., in press.
- Engle, D. (2010) Testimony before State Water Resources Control Board Delta Flow Criteria Informational Proceeding. Other Stressors-Water Quality: Ambient Ammonia Concentrations: Direct Toxicity and Indirect Effects on Food Web. Submitted to the State Water Resources Control Board, 40 pp. February 16, 2010.
- McCord, S., J. Walker, and D. Engle (2009) A pilot study using continuous ammonium sensors in the Sacramento River. Interagency Ecological Program (IEP) Workshop #5: Bay-Delta Monitoring Questions & Tools for the 21st Century, Sacramento, CA., October 9, 2009.
- Engle, D.L., and G. Lau (2009) Total and Un-ionized Ammonia Concentrations in the Upper San Francisco Estuary: A Comparison of Ambient Data and Toxicity Thresholds. 9th Biennial State of the San Francisco Estuary Conference, Oakland, CA, September 29-October 1, 2009.
- Engle, D., J. Walker, S. McCord, C. Irvine, and C. Williams (2009) Sacramento River Ammonia Pilot Study Results. Technical Memorandum submitted to the Interagency Ecological Program (IEP) Pelagic Organism Decline (POD)- Contaminants Work Team, August 13, 2009.
- Engle, D. (2009) Total Ammonia and Un-Ionized Ammonia Concentrations in the Delta. An Examination of Ambient Concentrations and Toxicity Thresholds. Central Valley Regional Water Quality Control Board Ammonia Summit, Sacramento, California, August 18-19, 2009.
- Altstatt, J., D.L. Engle, and K. Redmond (2009) Water quality characterization of the Channel Islands National Marine Sanctuary and Surrounding Waters. Submitted to National Oceanic and Atmospheric Administration, Channel Islands National Marine Sanctuary, May 2009. 229 pp.

- Larry Walker Associates (2009) Source Assessment Report: Nitrogen and Phosphorus in the Ventura River Watershed. Prepared for Ojai Valley Sanitary District, July 9, 2009. 55 pp. (author)
- Larry Walker Associates (2008) Calleguas Creek Nitrogen Compounds and Related Effects TMDL. Results of Special Study on Type and Extent of Algae Impairments. Prepared for the Calleguas Creek Watershed Management Plan, July 16, 2009. 93 pp (author).
- Engle D.L., J.M. Melack, R.D. Doyle and T.R. Fisher (2008) High rates of net primary production and turnover of floating grasses on the Amazon floodplain: Implications for aquatic respiration and regional CO₂ flux. *Global Change Biology*, 14 (2): 369-381. doi: 10.1111/j.1365-2486.2007.01481.x.
- Engle D.L., J. Sickman, C. Moore, A. Esperanza, J. Melack and J. Keeley (2008) The biogeochemical legacy of prescribed fire in a giant sequoia-mixed conifer forest of Sequoia National Park: A 16-year record of watershed balances. *Journal of Geophysical Research-Biogeosciences*, 113, G01014. doi:10.1029/2006JG000391
- Melack J.M. & Engle D.L. (2007) Carbon dynamics in Amazon floodplain lakes, 30th Congress of the International Association of Theoretical and Applied Limnology, August 2007, Montreal, Quebec.
- Engle D.L. (2006) Assessment of Coastal Water Resources and Watershed Conditions at Channel Islands National Park, California. Tech. Report NPS/NRWRD/NRTR-2006/354. 337 pp.
http://www.nature.nps.gov/water/watershed_reports/WSCondRpts.cfm
- Engle D.L. and J.L. Largier (2006) Assessment of Coastal Water Resources and Watershed Conditions at Cabrillo National Monument, California. Tech. Report NPS/NRWRD/NRTR-2006/355. 235 pp.
http://www.nature.nps.gov/water/watershed_reports/WSCondRpts.cfm
- Engle D.L. (2005) Pathogen Free Water - Molecular Probes for Safe Coastal Water, A Project Plan for the Global Solutions Institute, 65 pp.
- Engle D.L. (2002) Comparative analysis of high resolution remote sensing satellite systems: Landsat7, SPOT, IKONOS, ASTER, and RADARSAT. Prepared for the Japan External Trade Organization.
- Engle D.L. and J.M. Melack (2001) Ecological consequences of infrequent events in high-elevation lakes and streams of the Sierra Nevada, California. *Verh. Internat. Verein. Limnol.* 27: 3761-3765.
- Caron B., Gautier C., Landsfeld M. & Engle D. (2001) Earth Data Multimedia Instrument – EDMI: A NASA-funded showcase that brings research technology to secondary education. American Geophysical Union, December 2001, San Francisco, CA.
- Engle D. and J.M. Melack (2000) Methane emissions from an Amazon floodplain lake: Enhanced release during episodic mixing and during falling water. *Biogeochemistry* 51: 71-90.
- Engle D.L. and J.M. Melack (1997) Assessing the potential impact of acid deposition on high altitude aquatic ecosystems in California: Integrating ten years of investigation. Final Report. Prepared for the California Air Resources Board. Contract A093-312.
www.arb.ca.gov/research/abstracts/93-312.htm.
- Engle D.L. and J.M. Melack (1995) Zooplankton of high elevation lakes of the Sierra Nevada, California- Potential effects of chronic and episodic acidification. *Arch. Hydrobiol.* 133: 1-21.
- Engle D.L. (1993) Effects of suspended sediments on nutrient availability, algal growth and aquatic invertebrates of the Amazon floodplain. American Society of Limnology & Oceanography, Aquatic Sciences Meeting, June 1993, Edmonton, Alberta.

- Engle D.L. and J.M. Melack (1993) Consequences of riverine flooding for the seston and periphyton of floating meadows in an Amazon floodplain lake. *Limnology & Oceanography* 38: 1500-1520.
- Melack J.M., J.O. Sickman, F.V. Setaro and D. Engle (1993) Long-term studies of lakes and watersheds in the Sierra Nevada, patterns and processes of surface-water acidification. Final Report. Prepared for the California Air Resources Board. Contract A932-060.
- Engle D.L. (1992) Inundation of an Amazon floodplain lake during an unusually high flood year: consequences for seston and the periphyton of floating meadows. American Society of Limnology & Oceanography, Aquatic Sciences Meeting, February 1992, Santa Fe, NM.
- Melack J.M. & Engle D.L. (1991) Methane emissions from the Amazon floodplain: enhanced release during episodic mixing of lakes and a habitat-based regional assessment. 10th International Symposium on Environmental Biogeochemistry, August 1991, San Francisco, CA.
- Engle D.L. and O. Sarnelle (1990) Algal use of sedimentary phosphorus from an Amazon floodplain lake: Implications for total phosphorus analysis in turbid waters. *Limnology & Oceanography* 35: 483-490.
- Engle D.L. and J.M. Melack (1990) Floating meadow epiphyton: Biological and chemical features of epiphytic material in an Amazon floodplain lake. *Freshwater Biology* 23: 479-494.
- Fisher T.R., Doyle R.D., Moline M.A. & Engle D.L. (1989) Ecology of periphyton on the Amazon Floodplain. Symp. Floodplain Rivers, Baton Rouge, LO.
- Engle D.L. & Melack J.M. (1988) Epiphyton of floating meadows. 2nd Brazilian Conference of Limnology, July 1988, Cuiba, Mato Grosso, Brazil.
- Engle D.L. (1985) Haemoglobin production by *Daphnia pulex*; Intraspecific variation and its relation to habitat. *Freshwater Biology* 15: 631-638.

Awards and Honors:

- Ellen Schamberg Burley Scholarship, University of California: 1993
- University of California Regents Special Fellowship: 1985-1990
- Dissertation Year Fellowship, University of California Regents: 1990-1991
- National Science Foundation Pre-Doctoral Fellowship: 1985-1988
- James B. Angell Scholar, University of Michigan: 1983
- Class Honors, University of Michigan: 1981-1983
- Michigan Alumni Club Scholarship: 1979-1983
- W.J. Branstrom Prize for Academic Excellence: 1980
- University of Michigan Academic Recognition Scholarship: 1979
- Class Valedictorian, Damascus High School, Damascus, MD: 1979